PHYS 103 LAB 1 PERCEPTIONS, Estimates, Measurements, UNITS, And A BIT OF TRIG.

**Partner names:**……………………………...........

**Group name:**……………………………………

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Introduction

In this lab we will learn some basic tools that we will use throughout the course. You will find out why and when we need to measure things rather than just estimate them and how to compare two values for some quantity.

Part 1 Perceptions

Theory

We cannot always rely on human senses to make accurate observations. In **part 1** of this lab you will make some observations that should convince you about the validity of the above statement.

Remember, that accuracy of any measured quantity depends on the accuracy of the measuring device used. For example, you cannot measure the dimensions of your lab manual’s page more accurately then up to 1mm if you are using a meterstick as your measuring device. In science these inaccuracies of measurement are denoted in the following notation: say the length of a pen is 10 cm, and you used a ruler with the smallest division of 1mm to measure it i.e. the accuracy of your measurement is 1mm; you then write

Length of the pen = 10 cm ± 1mm or 10 ± 0.1 cm

This means that the pen can be anywhere from 9.9 cm to 10.1 cm long. Using that ruler, you are simply not able to ascertain the measurement any more precisely. Here 1mm is your measurement uncertainty.

Procedure

1. Observe the diagonal lines A and B in figure 1. Which line A or B looks longer?

A

B

**Figure 1.**

1. Measure the lengths of the two diagonal lines in figure 1. How do their lengths compare? Record your measurements, include measurement uncertainties.
2. Collect 20 pennies. Do they appear pretty much the same size and weight?
3. Using the electronic scale measure the weight of a penny. Record its weight and include measurement uncertainty.
4. Estimate how much 20 pennies would weigh. Show your calculations. What is the uncertainty of this estimate?
5. Place 20 pennies on the scale and measure their weight. Record their weight and include the measurement uncertainty.
6. Does the result agree with your estimate? If not, why not? What information does this measurement reveal that would otherwise go unnoticed?

Part 2 Estimates, and Measurements

Theory

In this part of today’s lab, you will estimate and then measure some physical quantities and compare the two results.

The ability to estimate quantities is important in physics as well as many other fields. Estimation consists of quickly making an "educated guess." Some people are better at it than others, but it is possible to improve with practice. Even "poor" estimators can do rather well when they focus on the task and use a system of units which is familiar to them.

To evaluate your estimating skills, you need to know how to compare your estimated value to a carefully measured one. To compare two values obtained by whatever means we calculate the percent difference. The percent difference is the positive difference between the two values e.g. x1 and x2 divided by that one of the two values which is considered to be more accurate – say x2, and multiplied by 100%. In equation form this looks like

(1)

where the straight vertical lines (absolute value signs) indicate that you take the positive value of the quantity between them. Percent difference tells us how far off x1 is from x2 in percentage terms. In this part of today’s lab, you are asked first to estimate the sizes of some objects, then to measure them, and finally to compare these two values by calculating the percent difference.

You will frequently need to compare your measured value to some standard and/or a more precisely previously determined value of a particular physical quantity. That established value is called the accepted value and since that value becomes our benchmark, it then becomes 2 in equation (1). In some other cases you will measure the same quantity in two different ways. In these circumstances, when you calculate the percent difference in order to compare the two values, you choose as 2 the value that you consider the more accurate and/or more reliable.

Whenever you see an instruction to compare the values of two quantities in any experiment it means you should calculate the percent difference and then based on this result discuss how similar these values were.

#### Questions:

a) Which of the two values for the weight of the twenty pennies you found (**Part 1** steps 4 and **5**), the estimated or the measured one, would you consider to be more accurate?

b) Which value, the estimated or the measured one, will correspond to *x*1 and which will correspond *x*2 if you want to use equation (1) to compare them? Calculate the value of the % difference between them.

Part 3 Units

If someone asked you how far you drove today, the answer “10” would make no sense. Some unit of length such as feet, meters, miles, or kilometers would be needed in the answer. An answer to almost any physical problem is not complete if the units are omitted.

Almost all countries in the world (except Myanmar and the United States) use the SI system of units. In this system the meter is the fundamental unit of length, the kilogram is the fundamental unit of mass, the second is the fundamental unit of time, and the Celsius degree is the fundamental unit of temperature. For comparison, the US uses an old English system which has the foot as the unit of length, the pound as the unit of weight, the second as the unit of time, and the Fahrenheit degree as the unit of temperature.

In science today, essentially all books use SI units. This class is no exception. To help you with the conversion process, some common (approximate) equivalencies are listed in table 1 below:

**Table 1. Units Conversion Table** (NOTE: values are approximate).

1 centimeter = 0.39 inches 1 in = 2.54 cm

1 meter = 3.3 ft = 39 inches 1 ft = 0.305 meters = 30.5 cm

1 kilometer = 0.62 miles 1 mile = 1. 609 km

1 kg weighs 2.2 lb on Earth 1 lb weighs 0.45 kg on Earth

= =

#### Questions: (Be sure to include all calculations performed.)

1. What are the main advantages of the SI system?

b) A typical person in the US weighs 150 lb. How much does such person weigh in kilograms?

c) The average female height in United States is 5 feet and 3.5 inches. Convert it to centimeters.

d) Roughly estimate what distance from your college to your home in old English units (choose the distance for one partner). How much is that in SI units?

e) What is the normal driving speed in town in old English units and what is it in SI units?

f) How many meters are there in one kilometer?

g) How many millimeters are there in one kilometer?

h) What is the freezing temperature of water in the SI system?

i) How many square centimeters are there in one square meter?

j) How many cubic centimeters are there in one square meter?

k) How many cubic centimeters are there in one cubic meter?

l) What is your normal body temperature? Convert it to degrees Celsius.

m) Would you say that the statement “Typical room temperature in degrees Celsius is 20°C” is true or false? Convert this value to degrees Fahrenheit, check and justify your answer.

Part 4 A Bit of Trig

Theory

Trigonometry is a part of mathematics based on the properties of right triangles, i.e. triangles in which two sides are at 90° to each other. A sample right triangle is shown in figure 2 below. In this triangle side *a* is opposite angle θ , side *b* is adjacent to angle θ , and side *c*, which is opposite the 90° angle, is the hypotenuse of the triangle. The ratios of the lengths of the sides of such a triangle define basic trigonometric functions such as the sine (sin), cosine (cos), tangent (tan) of the angle θ in the following way:

sin θ = =

cos θ = =

tan θ = =

Also for a right triangle we have *a*2 + *b*2 = *c*2 (Pythagorean theorem).

Notice: since sine, cosine, and tangent are ratios of two lengths, they are quantities that do not have any units.

90°

***c***

***a***

***b***

φ

θ

Note: you can easily see that sin θ = cos φ and vice versa sin φ = cos θ. Additionally, since the sum of the angles in any triangle equals 180°, in a right triangle θ + φ= 90° which implies that sin (90°- φ) = cos φandcos (90°- φ) = sin φ

**Figure 2.**

The values of sine, cosine, and tangent for any particular angle θ can be easily found using a calculator. Make sure you set your calculator in the proper mode to enter the angle in degrees. Table 2 below lists some values of sine, cosine, and tangent for frequently used angles. See if you get these values with your calculator.

**Table 2.**

|  |  |  |  |
| --- | --- | --- | --- |
| **angle θ (°)** | **sin θ** | **cos θ** | **tan θ** |
| 0 | 0 | 1 | 0 |
| 30 |  | ≈ 0.866 | 0.577 |
| 45 | ≈ 0.707 | ≈ 0.707 | 1 |
| 60 | ≈ 0.866 |  | 1.732 |
| 90 | 1 | 0 | ∞ |

What if we want to go the other way? Let’s say we know the sizes of the triangle sides and we want to find the angles? For example: *a* = 4 inches and *b* =3 inches. We can easily find tan θ = *a*/*b* = 4/3*.* But what aboutthe angleθ itself?

There are functions called arcsine, arccosine, arctangent that will give us the answers. So if tan θ = 4/3 then

θ = arctan (4/3). This is called an inverse function since it finds the argument for a given value.

How do we find these arc functions? Use a calculator. On your calculator these functions may be denoted by symbols such as sin-1, cos-1 and tan-1, respectively. I don’t like this notation since sin-1 may easily be taken to mean which an entirely different thing. Your PC calculator will do inv sin etc. Try it. In our example θ *=* arctan (4/3) = 53°. Try a few others from the table: e.g. is arccos (0.5) = 60° or arcsin (0.707) = 45°?

Procedure

1. Take a sheet of quad ruled paper and a ruler or triangle and sketch a right triangle with sides that are similar to what is shown in figure 3a below:

**θ**

**hypotenuse**

**opposite**

**adjacent**

**Figure 3a) b)**

1. We will refer to the sides of the triangle in relation to angle θ as indicated in figure 3b above.
2. Use a ruler to measure the actual lengths of each side of your triangle. Record your measurements in table 3 below in the first row designated for triangle #1.
3. Use your measurements to find the sine, cosine, and tangent of angle θ for triangle #1.

**Table 3**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Triangle #** | **opposite (cm)** | **adjacent (cm)** | **hypotenuse (cm)** | **sin ** | **cos ** | **tan ** |
| **1** |  |  |  |  |  |  |
| **2** |  |  |  |  |  |  |
| **3** |  |  |  |  |  |  |

1. Double the length of the hypotenuse and then fill in the adjacent and the opposite (see figure 4 below). What effect does doubling the hypotenuse have on the adjacent and opposite sides?

**Figure 4.**

1. Use a ruler to measure the actual length of each side of your new triangle. Record your measurements in table 3 in the second row designated for triangle #2.
2. Use your measurements to find the sine, the cosine and the tangent of angle θ for triangle #2.
3. Triple the length of the hypotenuse (as compared with the original) and remeasure the sides and record your results in the row for triangle #3. Find the sine, cosine, and tangent of angle θ for triangle #3.
4. Within your measurement accuracy, are the values for sin θ, cos θ, and tan θthe same for all three triangles? Should they be? Explain.

|  |  |  |  |
| --- | --- | --- | --- |
| **Table 4.**   1. In table 4 average your values for sin θ, cos θ, and tan θ from table 3 and then use the arcsine, arccos and arctan functions to find your best estimates for angle θ. | **sin ** | **cos ** | **tan ** |
| **average** |  |  |  |
| **** |  |  |  |

1. In table 5 average three results for the angle θ obtained in table 4.
2. Measure angle θ using a protractor, record in table 5.
3. Compare the two values for angle θ by calculating the % difference. Do they agree? Discuss.

**Table 5.**

|  |  |
| --- | --- |
| **average  (°)** |  |
| **measured  (°)** |  |
| **% diff** |  |